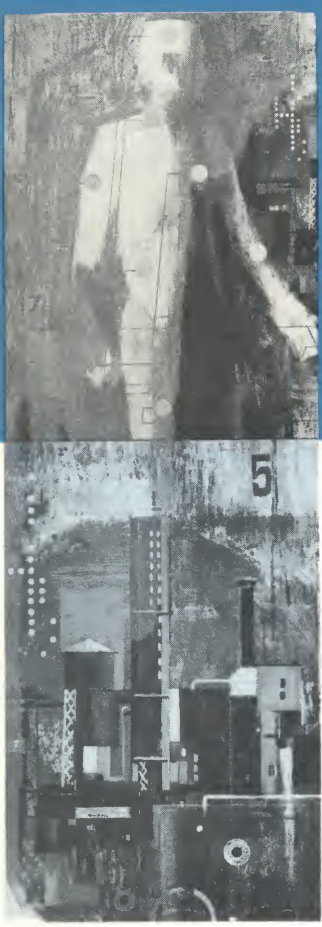

TECHNICAL MEASUREMENT CORPORATION

TMC **MNEMOTRON DIVISION**

CC-1 AUTO AND CROSSCORRELATION COMPUTER SYSTEM

ON-LINE OPERATION INCORPORATING VERSATILITY AND RELIABILITY

The Correlation Computer (Model CC-1) System is a multi-purpose electronic data analyzer consisting of the COR-256 and the CAT Model 400B. This Computer has the capability of performing real time auto- and crosscorrelation computations in addition to signal averaging of repetitive responses. The CAT (Computer of Average Transients) is also capable of performing on-line amplitude density spectra measurements as well as various types of histograms. As a correlation computer, the system permits the study of statistical properties of signals masked by random noise.

The system computes up to 256 points of the auto- and crosscorrelation functions. These computations are performed in real time (on-line) which makes the system especially valuable in research applications where previous methods involving large scale computers have been both costly and time consuming. The "on-line" process makes it possible for the experimenter to direct the course of the experiment while it is actually occurring.

The usable frequency range from DC to 100 cps makes it useful for experimental work in such fields as biomedical research, geophysical and astronomic observation, control system analysis, industrial process control, as well as many other specialized applications. The effective upper frequency may be increased with the use of tape recorded data reproduced at a slower speed.

The resultant correlogram can be continuously monitored on the CAT oscilloscope. Accessory equipment for readout of digital data and analog plots is available as part of the standard TMC-MNEMOTRON product line.

The auto- and crosscorrelation functions are defined as mathematical operations upon time series functions in the time domain. Basically, they provide for the statistical analysis of signals within noise and lead to the measurement of power spectral densities. Crosscorrelation measures the amount of dependency existing between two random signals. Furthermore, it is useful to detect common frequencies within these random signals if they exist. Autocorrelation performs a similar analysis upon a single variable and provides for the detection of periodic components masked by random activity.

Mathematically, the crosscorrelation function is defined as

$$\Phi_{fg}(\tau) = \lim_{T \to \infty} \int_0^T f(t) g(t-\tau) dt$$

where τ is the independent time delay variable, T is the period of integration, and f(t) and g(t) are the stationary and ergodic time series functions being considered. For autocorrelation, $g(t-\tau)$ is replaced by the delayed function $f(t-\tau)$.

$$\therefore \; \Phi_{ff}(\tau) = \lim_{T \to \infty} \int_0^T f(t) f(t-\tau) dt$$

The use of solid state circuitry has resulted in a compact lightweight system ideally suited to situations where portability is required. This has been achieved without sacrifice of performance or reliability. Clearly defined controls have been provided for simplicity of operation.

The COR and CAT are each housed in plastic-metal cabinets. The components are mounted on TMC-MNEMOTRON plug-in type printed circuit boards of proven reliability and are readily accessible by removing the side panels. Interconnection cables and complete operating instructions are provided with each system.

SPECIFICATIONS

Computations Performed:

Computations performed are auto- or crosscorrelation functions of the input variables. Specifically

$$\Phi(n\Delta\tau) = \sum_{j=0}^{T} f(t_j) g(t_j - n\Delta\tau)\Delta t \quad n = 0,1,2,3,\ldots$$

where f(t) and g(t) are the input functions, T the time for summation, $\Delta\tau$ the delay increment, and n the number of points computed. For autocorrelation f(t) and g(t) are the same variable. The basic system permits computations for $\Delta\tau$ positive. For crosscorrelation the negative half of the correlogram may be obtained by interchanging f(t) and g(t). A front panel control is provided to facilitate this change.

Inputs:

Two inputs may be fed from a single or double ended source, ± 3 Volts maximum input with respect to the return conductor. Floating input accepts DC levels up to 500 Volts maximum with respect to chassis ground. Input impedance 20K ohms.

Delay Increments:

The selection of the basic delay increment determines the number of points of the correlation function to be computed (See Data Frequency Range). Delay increments are selected by switches on the CAT and COR. The minimum increment is 2.5 ms. This may be multiplied by powers of 2 using appropriate switch positions. The maximum delay increment is 640 ms with the basic system but may be extended on special request.

Number of Correlation Points Computed:

32, 64, 128, or 256 by switch selection.

Integration Time:

Theoretically, the integration time must be at least 10 times the period of the lowest frequency being considered. However, depending upon the signal-to-noise ratio, this integration period may have to be increased 1 to 2 orders of magnitude. No maximum integration time restriction is made.

Data Frequency Range:

For each selection of delay increment a minimum and maximum data frequency exists for which the computation is optimally suited. A lower frequency limit may be determined by the number of complete correlation periods desired. Maximum frequency is that frequency for which an acceptable minimum number of samples per cycle is performed. These frequencies may vary from case to case. However, 4 cycles per total delay time and 4 samples per cycle are generally found to be acceptable values.

Number of Points of Correlation Function	Delay Increment ms	Total Delay ms	Max. Freq. for 4 points per cycle cps	Min. Freq. for 4 periods per total delay time cps
32	2.5	80	100	50
64	5	320	50	12.5
128	10	1280	25	3.1
256	20	5120	12.5	0.8

Each delay increment shown in the table (and, therefore, the total delay) can be multiplied by 2, 4, 8, 16, or 32 by appropriate settings of the switches. In each case the corresponding frequencies listed are divided by the same factor.

Accuracy:

Input Analog-Digital Conversion is 9 bits or one part in 512. Autocorrelation function of a ± 3 Volt 1 cps square wave of 100 cycles duration is triangular with less than 0.1% departure from linearity.

Normalization:

The last selected channel in the CAT is used to compute a normalizing constant to permit comparison of computations performed for different integration times.

Output:

The computed results are contained in the CAT Computer and are available as an oscilloscope pattern, analog plot, or decimal/digital printout or punchout with the use of accessory equipment.

Test Mode:

A built-in function generator provides a square-wave test signal to assure proper operation of the overall system.

Power Requirements:

100, 115, 200, 215, and 230 VAC; 50 to 400 cps. Total power consumption of the CC-1 system is 65 watts.

Physical Dimensions:

Two identical cases, each having overall dimensions of 8½" wide x 10¼" high x 22" deep.

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TMC MNEMOTRON DIVISION

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